ADVANCED TECHNOLOGY PROGRAM

PERFORMANCE OF COMPLETED PROJECTS

STATUS REPORT NUMBER 1

WILLIAM F. LONG

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Economic Assessment Office
Advanced Technology Program
Gaithersburg, Maryland 20899

William F. Long
Business Performance Research Associates, Inc.
Bethesda, Maryland 20814

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Certain trade names and products are mentioned in the text and tables of the report in order to adequately identify the commercial accomplishments to date deriving from completed ATP-funded research projects. In no case does such identification imply recommendation or endorsement by the National Institute of Standards and Technology.

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The opinions expressed in this report are those of the author, and do not necessarily express those of the Advanced Technology Program, the National Institute of Standards and Technology, the Technology Administration, or the Department of Commerce. And, of course, any errors as to factual information are the responsibility of the author.

Executive Summary

Innovations that reduce the costs and improve the outcomes of medical care, improve the clarity of wireless communications, and enhance the quality of manufactured products are among the many significant achievements supported by the Advanced Technology Program (ATP).

The First Group of Completed ATP Projects

This review of the first group of completed projects suggests that billions of dollars are likely to flow into the U.S. economy, greatly exceeding the ATP's investment. Thus, the ATP appears to be on track in fulfilling its mission to stimulate economic growth by helping American companies and their research partners overcome significant technical challenges to produce economically valuable new technologies. The details are contained in this report.

Background

During the period 1990 through 1998, the ATP — the nation's civilian technology program charged with improving the competitiveness of U.S. businesses — announced 431 multi-year research project awards as a result of 39 merit-based, peer-review competitions. These projects cost a total of approximately $2.8 billion, of which industry committed slightly more than half, and the ATP the remainder.

More than 1,000 participants are involved in the single-applicant and joint venture projects. For-profit companies, universities, non-profit laboratories, and federal laboratories serve as formal and informal partners and subcontractors.

ATP-funded projects are characterized by ambitious scientific and technological goals with strong potential to accelerate the development of technologies that offer substantial economic returns to the United States. The benefits to the nation are expected to extend well beyond the direct benefits to the ATP award recipients. The ATP is administered by the National Institute of Standards and Technology (NIST), which is part of the Department of Commerce's Technology Administration.

Report Objective, Scope and Approach

Policy makers and other observers are keenly interested in how ATP-funded research projects are turning out, what technologies have been developed thus far, whether these technologies have yet been embodied in commercial products and processes, and the impact that ATP-funded research has made on the U.S. economy. By the end of March 1997, 38 of all research projects then announced had been completed and 12 others had been terminated.

This report — which is just one element of the ATP's evaluation program — provides an assessment of the status of these projects. It contains a general analysis of the 38 projects as a group, touching on important technology and commercialization issues by looking at several across-the-board factors. It also provides a snapshot of each of the 38 completed projects, describing the context in which it unfolded, noting major accomplishments as of mid-1998, and highlighting the future outlook for continued progress. The 12 terminated projects are treated in Appendix B.

It is important to note that this set of completed projects constitutes only a portion of ATP's portfolio, and that it is not a representative sample but simply the first group to be completed at the time the report was initiated. Because the technology development efforts are for the most part still works in progress, this report is not expected to be the last word on their accomplishments. It remains the task of future studies to provide a more comprehensive assessment of their long-run impacts.

Overview of Completed Projects

The 38 completed projects were carried out by 34 single applicants — mostly small companies — and 4 joint venture teams. The 55 participants came from 21 states. The projects addressed technical challenges in 7 key industrial sectors: 15 projects involved research in electronics, 6 in computing, information, and communications, 5 in biotechnology, 4 in energy and environment, 4 in manufacturing, 3 in materials, and 1 in chemicals and chemical processing.

The median duration of these projects was 3 years. The ATP contributed a total of $64.6 million to the 38 projects, accounting for slightly less than half of the total costs of the projects, and project participants contributed $65.7 million. The ATP contributed another $9.4 million to the 12 projects that were terminated before completion, bringing the total ATP spending on these 50 projects to $74.0 million.

Projected Broad-Based Economic Benefits

Although it is beyond the scope of this status report to calculate the economic returns from each individual project, an "investment portfolio" approach can be used to evaluate ATP's investment across the group of funded projects, much as an investor in stocks and bonds might do.

Other economic studies have already projected future returns from three of the completed projects, as follows: from the **Auto Body Consortium** "2mm" project — at least $3 billion from quality improvements in U.S.-produced automobiles and associated market share gains; and from two medical technologies still in clinical trials (**Aastrom Biosciences'** stem cell production system and **Tissue Engineering's** prothesis material) a projected return of several billions of dollars.

Based on these figures, the estimated economic benefits to the nation resulting from just these three projects would exceed the ATP's costs for all 38 completed projects as well as the 12 terminated projects — indeed, the estimated benefits would exceed the total costs of all projects funded to date by the ATP. Furthermore, the returns could be much higher, given the considerable evidence that some of the other projects will also provide substantial economic benefits to the nation.

New Technologies; Early Products and Processes

The research conducted in the 38 completed projects produced a number of scientific discoveries, contributed to the U.S. knowledge base, and produced a number of breakthrough technologies. Although the full benefits of the technical achievements of the ATP projects will not be realized until more time has passed, allowing for their wider diffusion, the creation of technical knowledge and its diffusion to date represent critical first steps in realizing real-world benefits for the nation.

For 24 of the projects the new technologies have already been incorporated in new or improved commercial products or processes through the commercialization efforts of the companies. These products and processes include applications envisioned in the original proposals submitted to the ATP as well as unanticipated early spin-offs which exploit opportunities arising in the serendipitous process of discovery. Early revenue generation is important, particularly to small companies which must keep a close eye on cash flow for solvency. This early commercialization of the new technologies represents another critical step in the delivery of practical national benefits.

A few examples, illustrative of the technology development and commercialization achievements to date, are given below.

Technology Development and Commercialization Examples

Engineering Animation, in Ames, Iowa, developed core algorithms to enable the creation of three-dimensional images from sets of two-dimensional cross-sectional images of human body parts, and to provide animation for selected organs. After an initial failure to commercialize a high-cost system that incorporated the technology, the company adapted the technology for three CD-ROMs and two print publications in 1995, and has more recently created CD-ROMs that are bundled with medical books and sold as a package.

The company is now active in a multiplicity of applications featuring three-dimensional animations which utilize computer visualization and computational dynamics, in sectors as diverse as medical education, manufacturing design, and entertainment. The company started receiving outside recognition for its technical progress in 1994, while it was working on the ATP project. Since the project ended in 1995, it has experienced outstanding growth as its technology has been applied to more and more fields, and it has been recently recognized by *Individual Investor*, *Business Week*, and *Forbes ASAP* magazines as one of the best technology companies in the country.

Illinois Superconductor, in Mount Prospect, Illinois, developed new processes for fabricating thick-film, high-temperature superconducting (HTS) materials and demonstrated their use in wireless communications. By finding a way to make HTS coatings on inexpensive substrates, the company overcame the substantial difficulties involved in making the large, geometrically complex components needed to handle the radio frequency spectrum.

Superconducting components lower costs and improve services by extending the range of signal transmission, increasing receiver sensitivity, and improving frequency stability, thereby extending the range of base stations and reducing the numbers of base stations needed. The new technologies have been incorporated into commercial products that are already being used in 12 cities.

The **Auto Body Consortium**, a Michigan-based joint venture — a group of small- and medium-sized auto tooling and engineering service suppliers, two universities and two auto manufacturers — solved an assortment of long-standing problems on assembly lines by developing new measurement and process control technologies that cut dimensional variation in auto body assembly down to a world-class standard of two millimeters and below. A tighter fit results in higher-quality vehicles and reduced costs.

The new technologies have been incorporated by suppliers in assembly line equipment and put to use in 6 of 10 Chrysler plants and 16 of 31 General Motors plants in the United States and Canada. Net production costs have been reduced by an estimated $10 to $25 per vehicle, translating into millions of dollars of savings per year in plants now using the new technologies. The project team has also published a manual on the new technologies to help extend their use throughout the supply chain and the aerospace, appliance, metal furniture, and other industries that use automation to assemble metal parts.

Peer Recognition of Technical Achievements

The technical achievements of some of the completed projects were honored by outside organizations, including trade associations and technical journals. In 1996 alone, the following six awards were given:

- *R&D* magazine — an R&D 100 award to **American Superconductor**, in Westborough, Massachusetts, for its development of CryoSaver current leads;
- *Industry Week* magazine — one of 25 Technology of the Year Awards to **American Superconductor**, for applications of superconducting wire;
- *Industry Week* magazine — one of 25 Technology of the Year Awards to **Engineering Animation**, in Ames, Iowa, for its interactive 3D visualization products used in the manufacturing sector for product development;
- *Discover* magazine — one of 36 finalists for Technology of the Year to **HelpMate Robotics**, in Danbury, Connecticut, for the HelpMate robot used in hospitals;
- *Microwave & RF* magazine — one of the Top Products of 1996 to **Illinois Superconductor**, in Mt. Prospect, Illinois, for cellular phone site filters and superconducting ceramics;
- *Computerworld* magazine — finalist for the Smithsonian Innovator Medal to **Molecular Simulations**, in San Diego, California, for advances in software to help scientists simulate and visualize complex molecules.

Dissemination of New Technical Knowledge

The new knowledge and technologies are being disseminated widely to promote broader application across the economy and further broad-based benefits. Dissemination takes place in several ways. For instance, inventions that are both novel and useful can be patented and licensed to others for their use. Of the 38 completed projects, 15 have been granted patents so far, and three projects produced at least 5 patents each. For some projects, patent applications have been filed but the patent has not yet been granted.

Products can be reverse engineered to determine the technology embedded in them. The substantial number of products thus far released to markets will further the dissemination of new technical knowledge. Other parties can not only use them but attempt to discover how they work by observation and testing.

Knowledge has also been shared through the numerous formal and informal arrangements with partners, intermediate customers, and end users, and through professional conferences and technical publications. Of the completed projects, 27 involved the sharing of technical information with a variety of collaborators: joint venture participants, subcontractors, and informal partners. Of the completed projects, 16 led to publications in technical and professional journals, and many awardees reported multiple publications — more than 20 in several cases.

Small Company Growth and Attraction of Capital

Besides the sales of products and processes incorporating ATP-funded advances, other signals also reveal that a company possesses valuable technology and is probably on the path toward commercialization. These signals include company growth and initial public offerings (IPOs) of stock.

Of the 27 small single-applicant awardees, 22 experienced some growth in employment, and 16 of these have at least doubled in size since the start of the ATP project. One company reported a 19-fold increase in staff. Of the 21 single-applicant awardees that were privately held at the beginning of their ATP projects, five companies raised capital for growth by conducting IPOs during the project, and a sixth did so afterwards.

Why ATP?

The ATP either made research and commercialization possible, or significantly accelerated it, according to company interviews. For 32 completed projects, 21 would not have been undertaken at all without ATP funding, and 11 would have begun at a later date and proceeded at a slower pace. (Personnel changes, severe company financial distress, or lack of clarity in responses to interview questions made it impossible to include six of the 38 projects in this tabulation.)

In addition, ATP funding significantly accelerated the time-to-market for the new technologies, according to the project participants. Of the 32 projects, 13 awardees said the ATP funding helped them raise additional capital, and 23 said it boosted their ability to find partners to pursue continued development and commercialization.

Examples of company comments about the role of the ATP include:

- **Torrent Systems** — It is doubtful that the technology could have been successfully developed at all; venture capital funding had been sought but was unavailable.
- **AlliedSignal** — The company would have needed another five years to reach this stage of development.
- **Diamond Semiconductor Group** — The company would have been unable to do the research or survive as a company; its only other alternative then was to become part of a foreign company.
- **Nonvolatile Electronics** — ATP funding enabled the project to be done, prevented the company from failing, and improved the company's ability to attract capital from other sources.
- **FSI International** — The award enabled FSI to collaborate with Massachusetts Institute of Technology researchers.
- **Light Age** — The visibility generated by winning the ATP award helped Light Age establish agreements with research partners and, coupled with the success of the ATP project, enabled it to secure additional funding from private investors.
- **Thomas Electronics** — Without the ATP award, the company would have struggled along with its conventional CRT technology and would have stood virtually no chance of competing with other display-component suppliers, all of which are foreign companies.

Introduction

Industry has proposed 3,585 projects to the ATP since 1990, of which 431, or 12 percent, have been selected by the ATP for funding. Fifty of the 431 ATP projects were either completed or terminated as of March 1997, which is when this study began. Of the 50 projects, 38 were completed, and 12 were terminated before completion. This study focuses on these first 38 completed projects. A series of sequential studies will address additional ATP projects as they are completed or terminated.

Technology Development Proposals to the ATP

Projects are proposed to the ATP by U.S. companies. Proposals that score high in terms of their scientific/technical merit and their economic merit are selected for ATP cost-share awards. The reviews are carried out in rigorous peer-review competitions. All proposals are reviewed by government scientists and engineers who are expert in the relevant technology areas. They are also reviewed by business, industry, and economic experts who judge the potential of the proposed project to deliver broadly based economic benefits to the nation — including large benefits extending beyond the award recipient, i.e., "spillovers". The ATP issues a proposal preparation kit that presents and explains the selection criteria to prospective proposers and provides guidance on preparing proposals.[1]

ATP Project Evaluation

The Economic Assessment Office (EAO) of the ATP is charged with evaluating the performance of funded projects. One element of the EAO's evaluation plan[2] is to provide an interim assessment of the status of all completed ATP projects, this being the first status report. Another element is to conduct detailed economic case studies of selected projects, several of which are drawn upon and referenced in this study. Other evaluation activities of the EAO include database development, surveys, statistical and econometric studies, model development, and special issues studies.[3]

"Completed" and "Terminated" Projects Defined

For the purposes of this study, a "completed" project is defined as one for which a final report has been filed with the ATP, the financial and other paperwork required for close-out has been done, and the National Institute for Standards and Technology (NIST) Grants Office has notified the ATP that it considers the project completed. A "terminated" project is defined as one that either was selected in an ATP competition and announced but never officially started, or one that started but was closed for some reason before the completion date, with a substantial amount of the technical work still unfinished.

Sources of Information

Information contained in the individual project reports in Chapters 2-8 comes from several sources: documents filed by project participants; conversations with ATP staff familiar with the project; public documents, such as patent data from the U.S. Patent and Trademark Office, academic and other professional literature, trade and business literature, news reports, and filings at the Securities and Exchange Commission; previous EAO studies; and interviews with company project staff. Each of the individual project write-ups was reviewed for accuracy by the awardee and ATP staff.

Report Organization

Chapter 1 provides a summary overview of the 38 completed projects as a group. First, the portfolio is characterized in terms of technologies, company size, and other features. Then, the timing of the various stages of technology development and commercialization is discussed. Evidence of the gains in technical knowledge is covered, as is dissemination of the new knowledge, with special attention to the availability of products and processes that have been introduced to the market. The chapter closes with an overview of the broad-based benefits that this portfolio of projects is likely to produce.

The individual project reports are presented in Chapters 2-8, organized by technology group. For each completed project, major accomplishments and the outlook for continued progress are highlighted. A detailed account of how the project has unfolded is given, with attention to technical and commercial goals and achievements, information about technology diffusion, and views about the role played by ATP's funding.

Appendix A presents brief descriptions of technical and commercial achievements of the completed projects in tabular form. Appendix B provides a brief discussion of the 12 terminated projects.